

CLAIMS

What is claimed is:

1. A method for imaging the spatial distribution and concentration level of macular carotenoids, the method comprising:

obtaining a light source that generates light at a wavelength that produces a Raman response with a wavelength shift for one or more macular carotenoids to be detected;

directing light from the light source onto macular tissue of an eye for which macular carotenoid levels are to be measured;

collecting light scattered from the macular tissue, the scattered light including elastically and inelastically scattered light, the inelastically scattered light having a plurality of Raman signals corresponding to the one or more macular carotenoids;

selectively removing the elastically scattered light;

analyzing the spatial position and intensity of the Raman signals in the inelastically scattered light; and

producing an image of the Raman signals, the image representing the spatial distribution and concentration level of the one or more macular carotenoids in the macular tissue.

2. The method of claim 1, wherein the light source generates light at a wavelength that overlaps the absorption bands of the one or more macular carotenoids to be detected.

3. The method of claim 1, wherein the light source generates light in a wavelength range from about 350 nm to about 550 nm.

4. The method of claim 1, wherein the light from the light source has an intensity that does not destroy the macular tissue and does not substantially alter carotenoid levels in the macular tissue.

5. The method of claim 1, wherein the light source generates light at an exposure spot size of about 5 microns to about 10 mm.

6. The method of claim 1, wherein the light source generates light with an exposure time of about 0.001 to about 100 seconds.

7. The method of claim 1, wherein the macular tissue resides in a live subject.

8. The method of claim 1, wherein the inelastically scattered light is analyzed at frequencies characteristic of macular carotenoids.

9. The method of claim 1, wherein the image of the Raman signals is an en face map.

10. The method of claim 1, wherein the image of the Raman signals is a topographical surface plot.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397
--	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

1000 EAGLE GATE TOWER

1000 EAGLE GATE TOWER

12. A method for imaging the spatial distribution and concentration level of selected materials in retinal tissue, the method comprising:

obtaining a light source that generates light at a wavelength that produces a Raman response with a wavelength shift for a material to be detected;

directing light from the light source onto retinal tissue of an eye for which levels of the material are to be measured;

collecting light scattered from the retinal tissue, the scattered light including elastically and inelastically scattered light, the inelastically scattered light having a plurality of Raman signals corresponding the material;

selectively removing the elastically scattered light;

analyzing the spatial position and intensity of the Raman signals in the inelastically scattered light; and

producing an image of the Raman signals, the image representing the spatial distribution and concentration level of the material in the retinal tissue.

13. An imaging apparatus, comprising:
- a light source that generates light at a wavelength giving a Raman response with a wavelength shift for one or more carotenoids to be detected;
 - a light delivery and collection means in optical communication with the light source for directing light onto tissue and collecting scattered light from the tissue;
 - wavelength selective means for selecting Raman shifted light from collected scattered light;
 - detection means for measuring the intensity of the Raman shifted light at frequencies characteristic of the one or more carotenoids to be detected;
 - analyzing means for determining the spatial position and intensity of Raman signals in the Raman shifted light; and
 - output means for producing an image of the Raman signals, the image representing the spatial distribution and concentration level of the one or more carotenoids.

14. The imaging apparatus of claim 13, wherein the light source generates light at a wavelength that overlaps the absorption bands of the one or more carotenoids to be detected.

15. The imaging apparatus of claim 13, wherein the light source generates light in a wavelength range from about 350 nm to about 550 nm.

16. The imaging apparatus of claim 13, wherein the light source generates light at an exposure spot size of about 5 microns to about 10 mm.

17. The imaging apparatus of claim 13, wherein the light source generates light with an exposure time of about 0.001 to about 100 seconds.

18. The imaging apparatus of claim 13, wherein the wavelength selective means is adapted to be angle tuned to alternately transmit Raman shifted light at an on peak wavelength position, or to transmit light at an off peak wavelength position.

19. The imaging apparatus of claim 13, wherein the wavelength selective means is adapted to simultaneously transmit Raman shifted light at an on peak wavelength position and to transmit light at an off peak wavelength position.

20. The imaging apparatus of claim 13, wherein the detection means comprises an optical detector array on a charge coupled device camera.

21. The imaging apparatus of claim 13, wherein the detection means comprises a discrete photo detector.

22. The imaging apparatus of claim 13, wherein the analyzing means comprises a computer.

23. The imaging apparatus of claim 13, wherein the output means comprises a visual display monitor.

24. The imaging apparatus of claim 13, wherein the output means comprises a printer.

25. The imaging apparatus of claim 13, wherein the image produced by the output means is an en face map.

26. The imaging apparatus of claim 13, wherein the image produced by the output means is a topographical surface plot.

2020 "E3B0400F"

WORKMAN, NYDEGGER & SEELEY
A PROFESSIONAL CORPORATION
ATTORNEYS AT LAW
1000 EAGLE GATE TOWER
60 EAST SOUTH TEMPLE
SALT LAKE CITY, UTAH 84111

27. An imaging apparatus, comprising:

a light source that generates light at a wavelength giving a Raman response with a wavelength shift for one or more carotenoids to be detected;

an optical module in optical communication with the light source, the optical module configured to direct light onto tissue and collect scattered light from the tissue;

one or more wavelength selective devices configured to select and transmit Raman shifted light from collected scattered light;

an optical detection device configured to measure the intensity of Raman shifted light at frequencies characteristic of the one or more carotenoids to be detected;

a data processing device operatively connected to the optical detection device, the data processing device adapted to determine the spatial position and intensity of Raman signals in the Raman shifted light; and

an output device adapted to display an image of the Raman signals, the image representing the spatial distribution and concentration level of the one or more carotenoids.

28. The imaging apparatus of claim 27, wherein the light source comprises a mercury arc lamp.

29. The imaging apparatus of claim 27, wherein the light source comprises an argon ion laser.

30. The imaging apparatus of claim 27, wherein the light source generates light in a wavelength range from about 350 nm to about 550 nm.

31. The imaging apparatus of claim 27, wherein the optical communication between the light source and the optical module is provided by a fiber optic bundle.

32. The imaging apparatus of claim 27, wherein the optical module comprises:
a collimating condenser lens;
a band pass filter in optical communication with the condenser lens; and
a dichroic or holographic beam splitter in optical communication with the band pass filter.

33. The imaging apparatus of claim 32, wherein the optical module further comprises a lens in optical communication with the beam splitter and configured to focus light onto the tissue and collect light scattered back from the tissue.

34. The imaging apparatus of claim 32, wherein the optical module further comprises a scanning-type instrument in optical communication with the beam splitter and configured to sequentially scan a light beam from point to point across the tissue.

35. The imaging apparatus of claim 27, wherein the one or more wavelength selective devices comprise a narrow band interference filter and a broad band interference filter.

36. The imaging apparatus of claim 35, wherein the narrow band interference filter is adapted to be angle tuned.

37. The imaging apparatus of claim 27, wherein the one or more wavelength selective devices comprise a fully blocked narrow band filter.

38. The imaging apparatus of claim 27, wherein the one or more wavelength selective devices are selected from the group consisting of acousto-optic tunable filters, and dispersion based devices.

39. The imaging apparatus of claim 27, wherein the optical detection device comprises an optical detector array on a charge coupled device camera.

40. The imaging apparatus of claim 27, wherein the optical detection device comprises a discrete photo detector.

41. The imaging apparatus of claim 40, wherein the discrete photo detector is selected from the group consisting of a photomultiplier tube, and an avalanche photo diode.

42. The imaging apparatus of claim 40, further comprising a pinhole aperture disposed in front of the discrete photo detector.

43. The imaging apparatus of claim 27, wherein the data processing device comprises a computer.

45. The imaging apparatus of claim 27, wherein the output device comprises a printer.

[illegible]